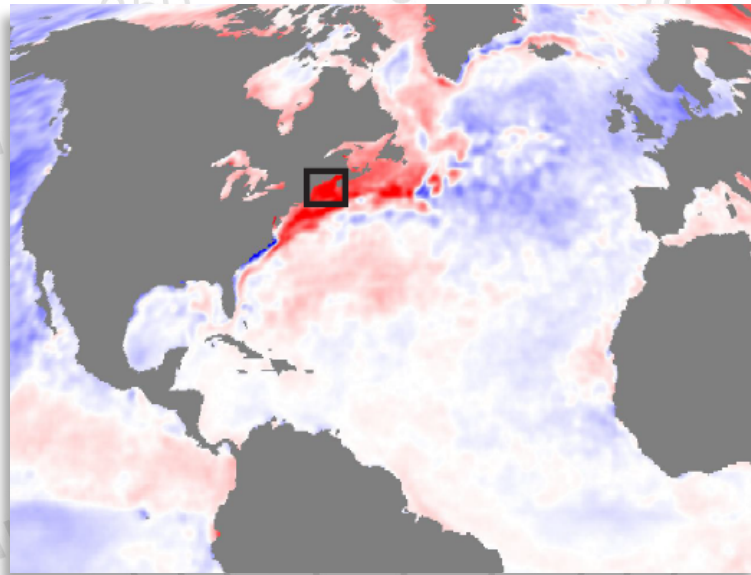


Warming Trends & Impacts in the Gulf of Maine



Andrew J. Pershing



**Gulf of Maine
Research Institute**

Science. Education. Community.

Outline

- Temperature trends in the Gulf of Maine
- Temperature & lobsters
- Temperature & cod

Acknowledgements:

Kathy Mills, Arnault Le Bris, Janet Nye, Lisa Kerr, Graham Sherwood, Rick Wahle, Andy Thomas



LENFEST
OCEAN
PROGRAM

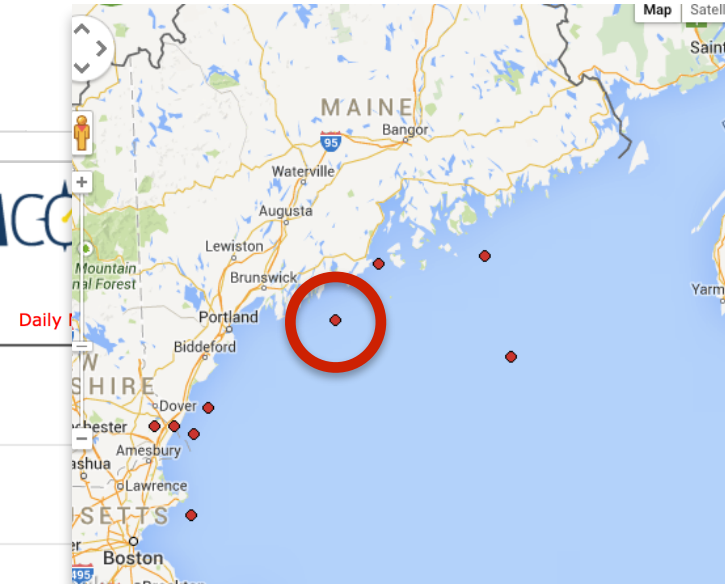
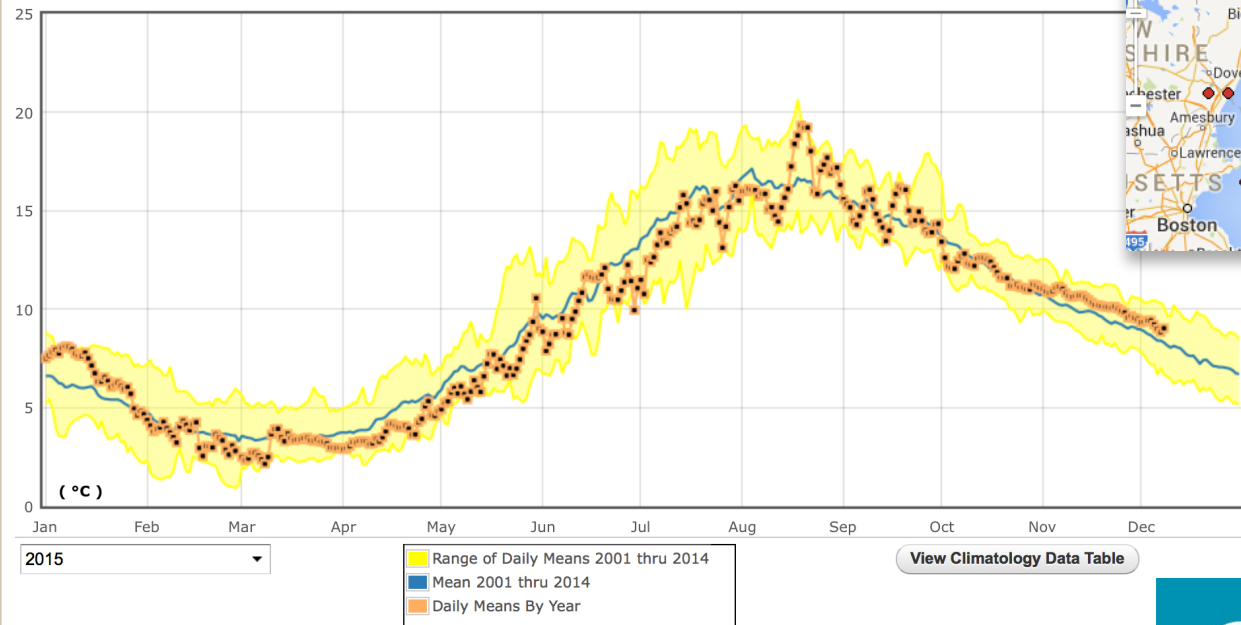
Climatology Viewer

For a list of Northeast Ocean Climate Data Sources, [click here](#).

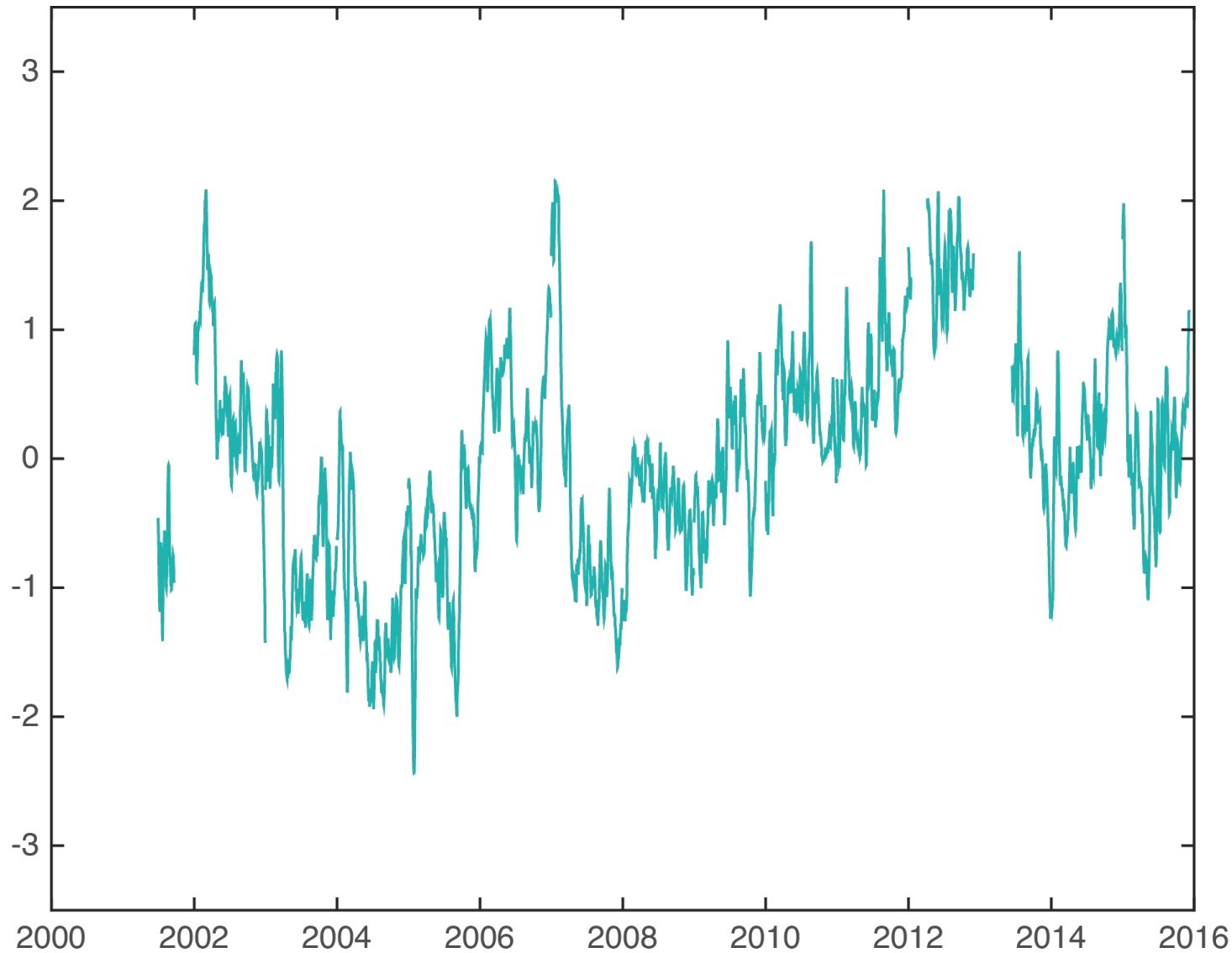
Buoy Location	Data Type	Averaging Time Period
E01, Central Maine Shelf - UMaine	Water Temperature 1m	Daily

NERACOOS

Mean Water Temperature 1 meter depth at E01 for 2001 thru 2015

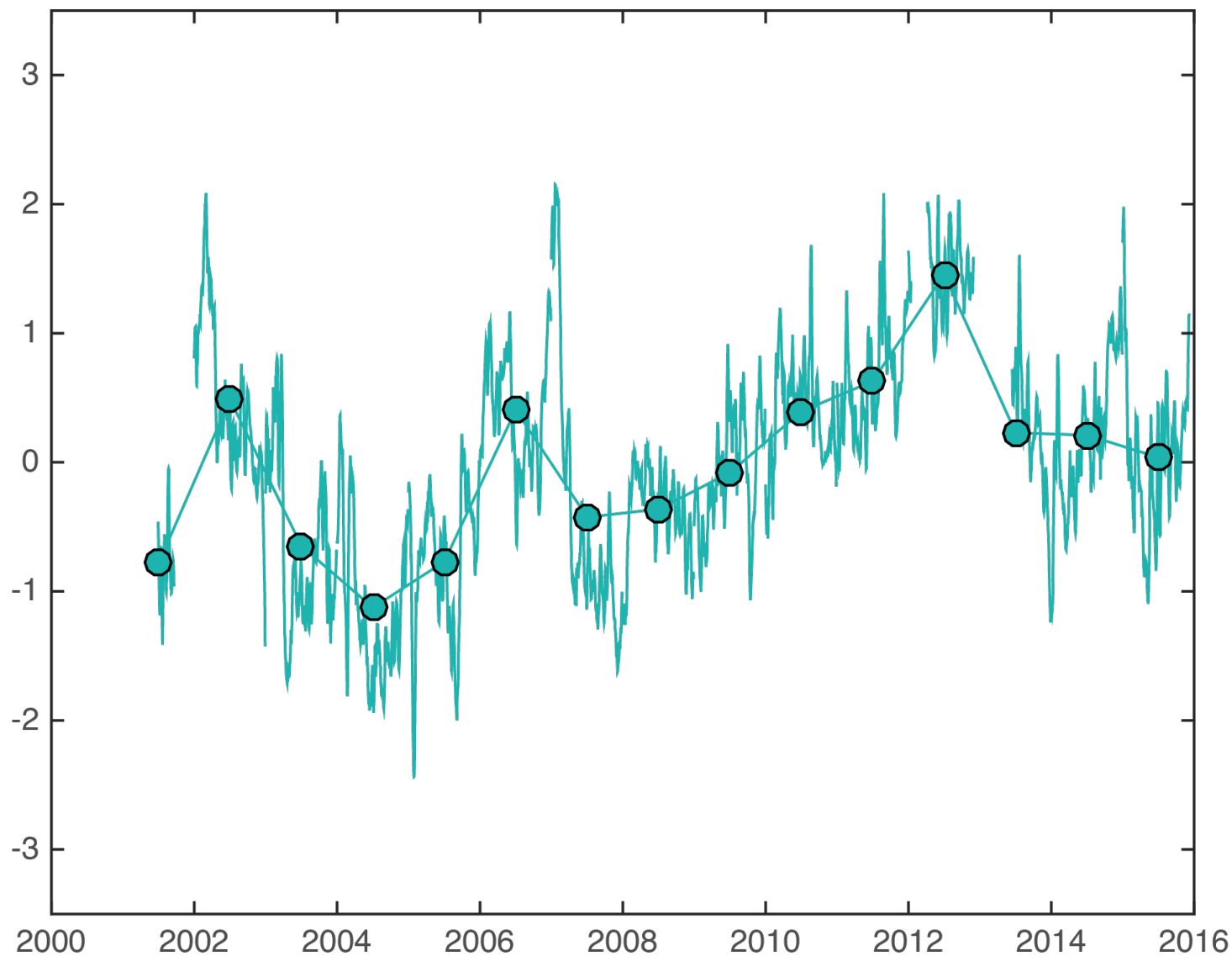


Buoy E Time Series



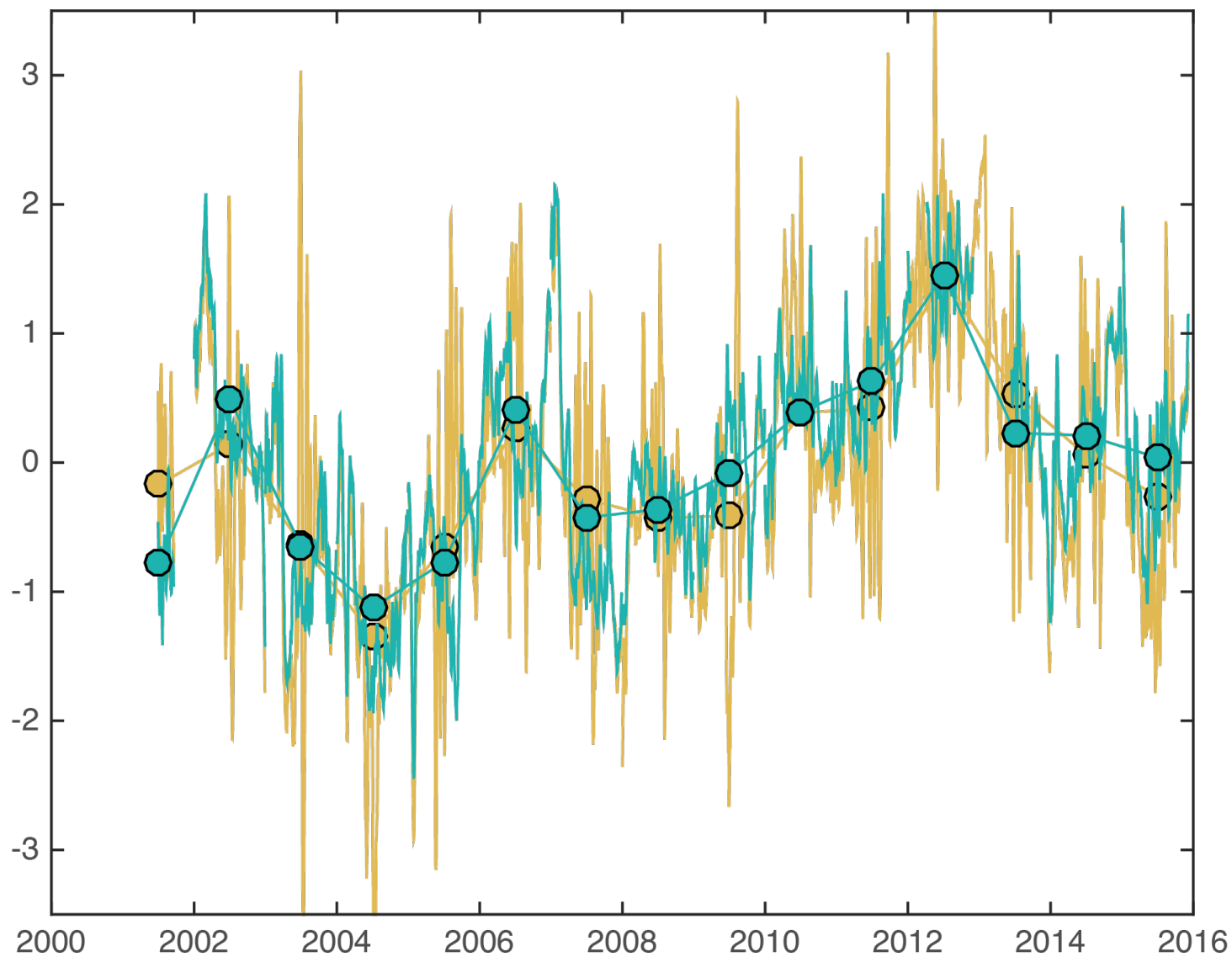
20m

Buoy E Time Series

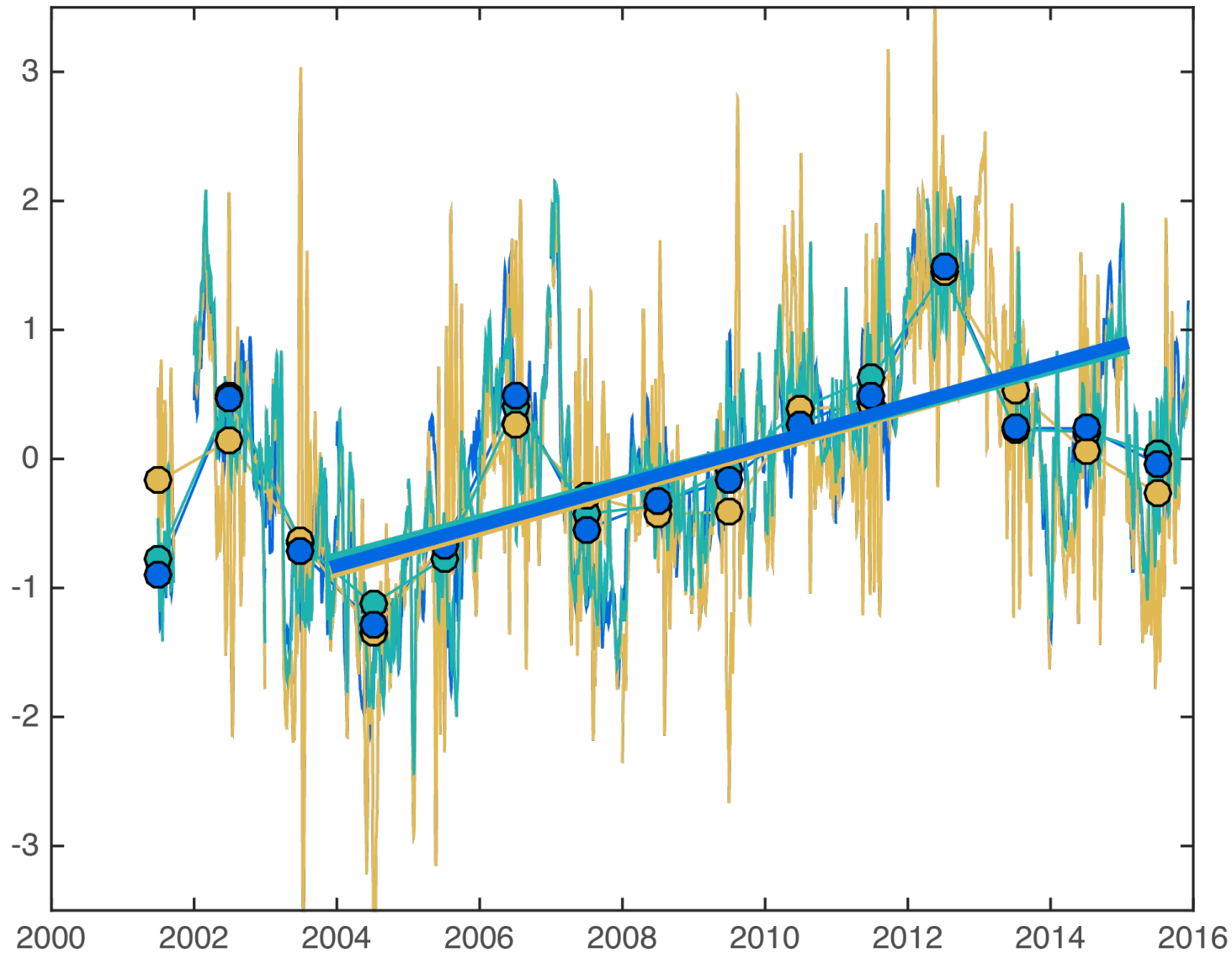


20m

Buoy E Time Series



Buoy E Time Series



10m

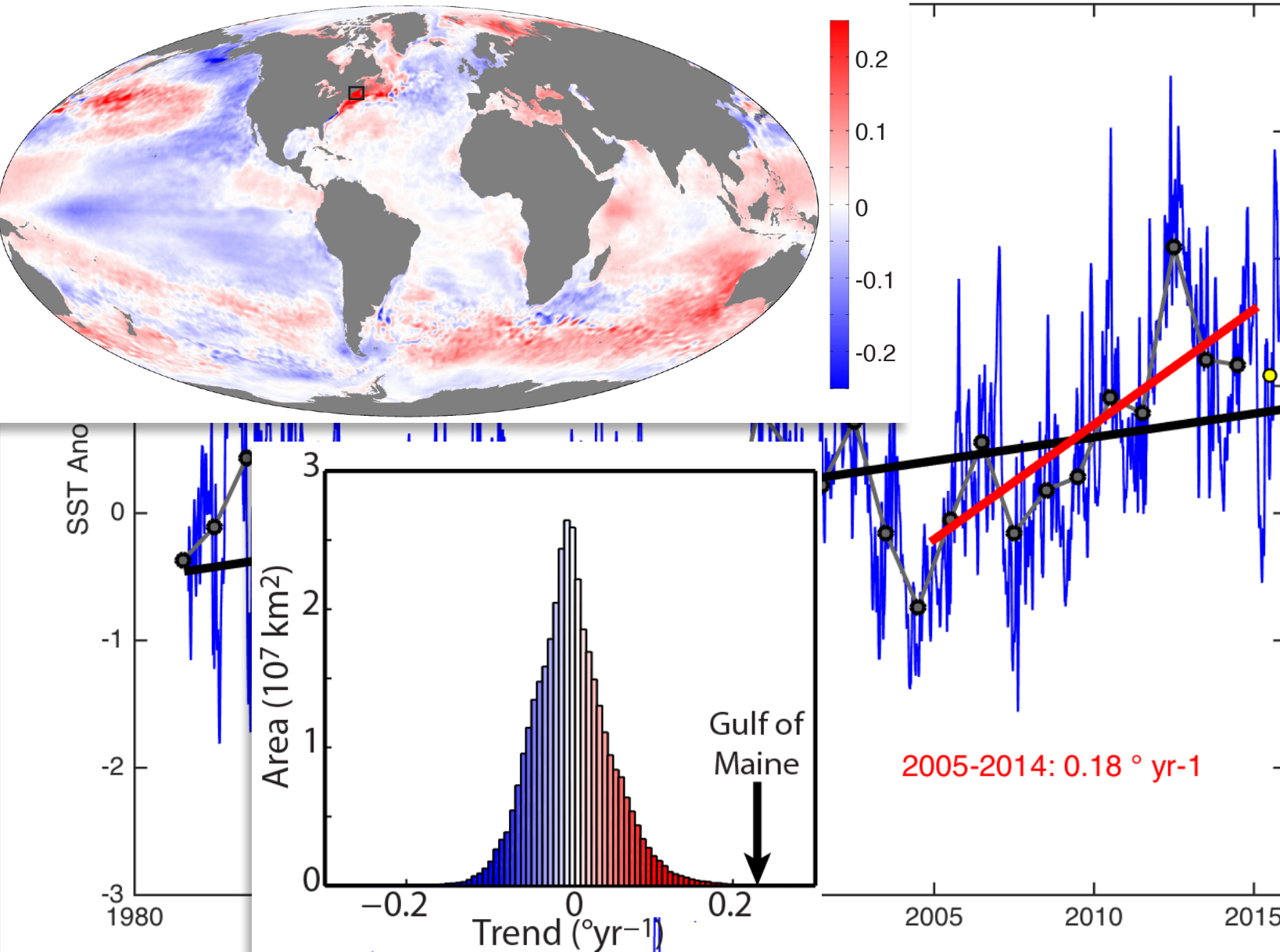
20m

50m

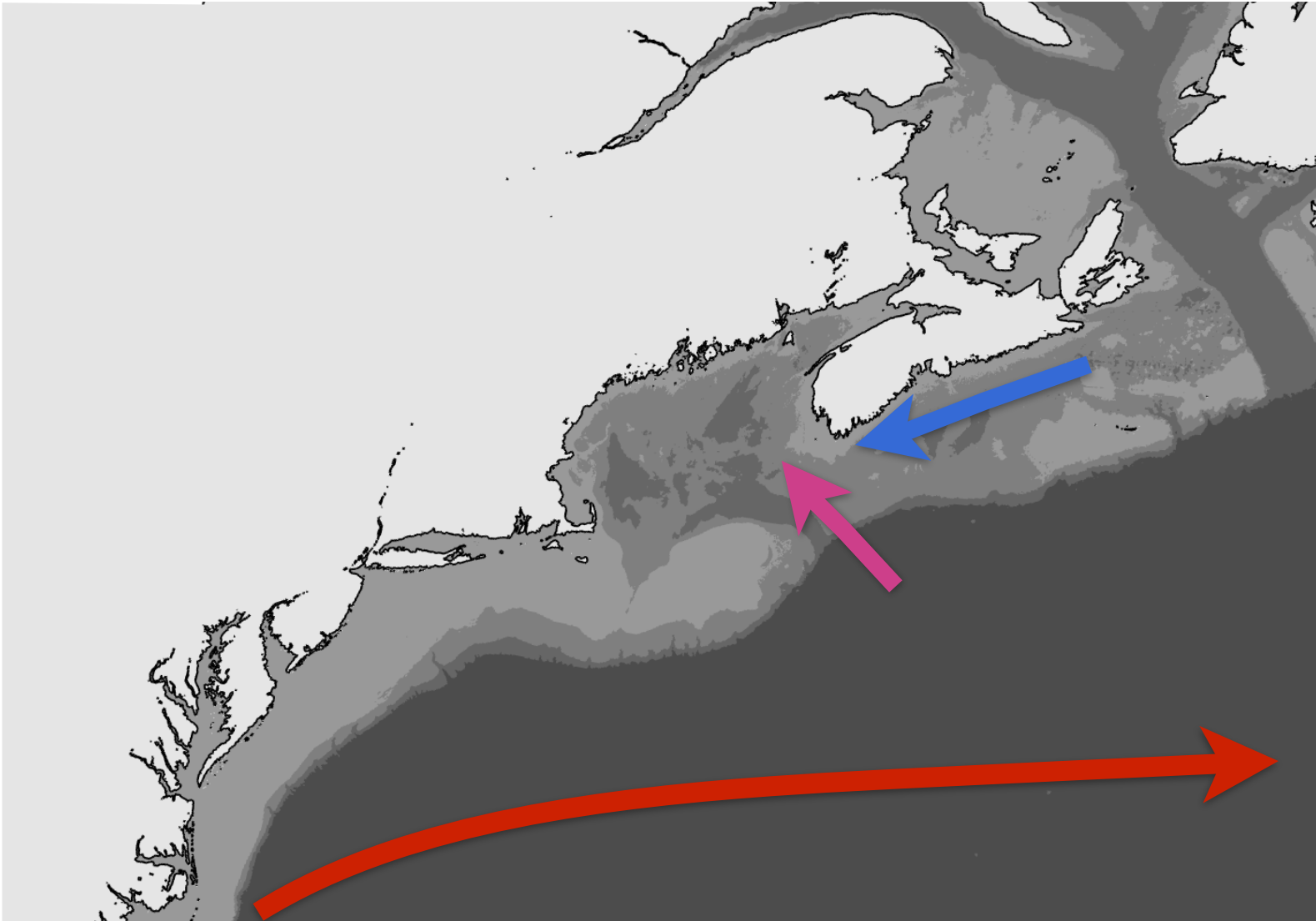
$0.15^{\circ} \text{ yr}^{-1}$

Gulf of Maine SST

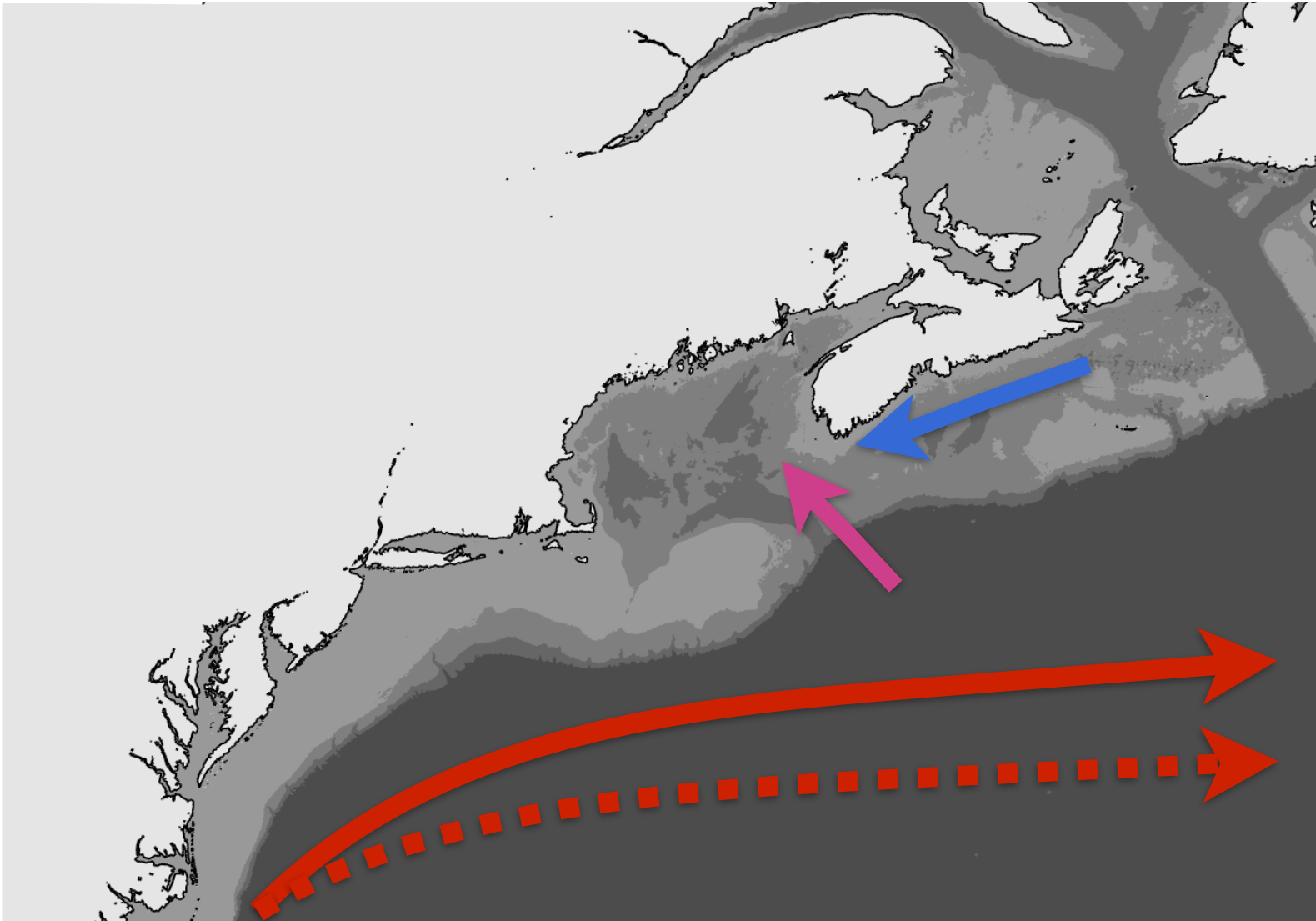
Gulf of Maine SST Anomalies from 1981 to 2014 (relative to 1982-2011)



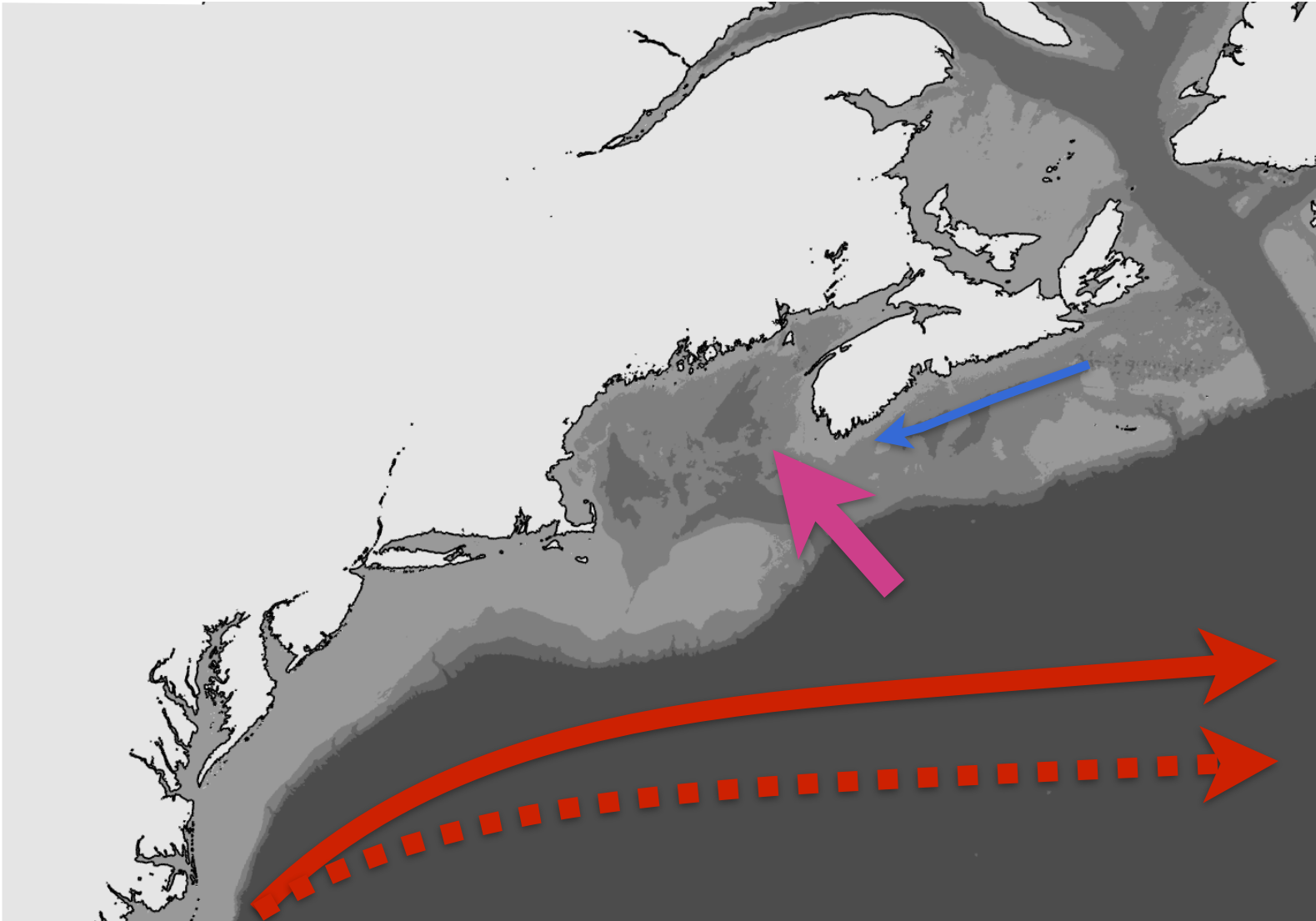
Gulf of Maine Warming



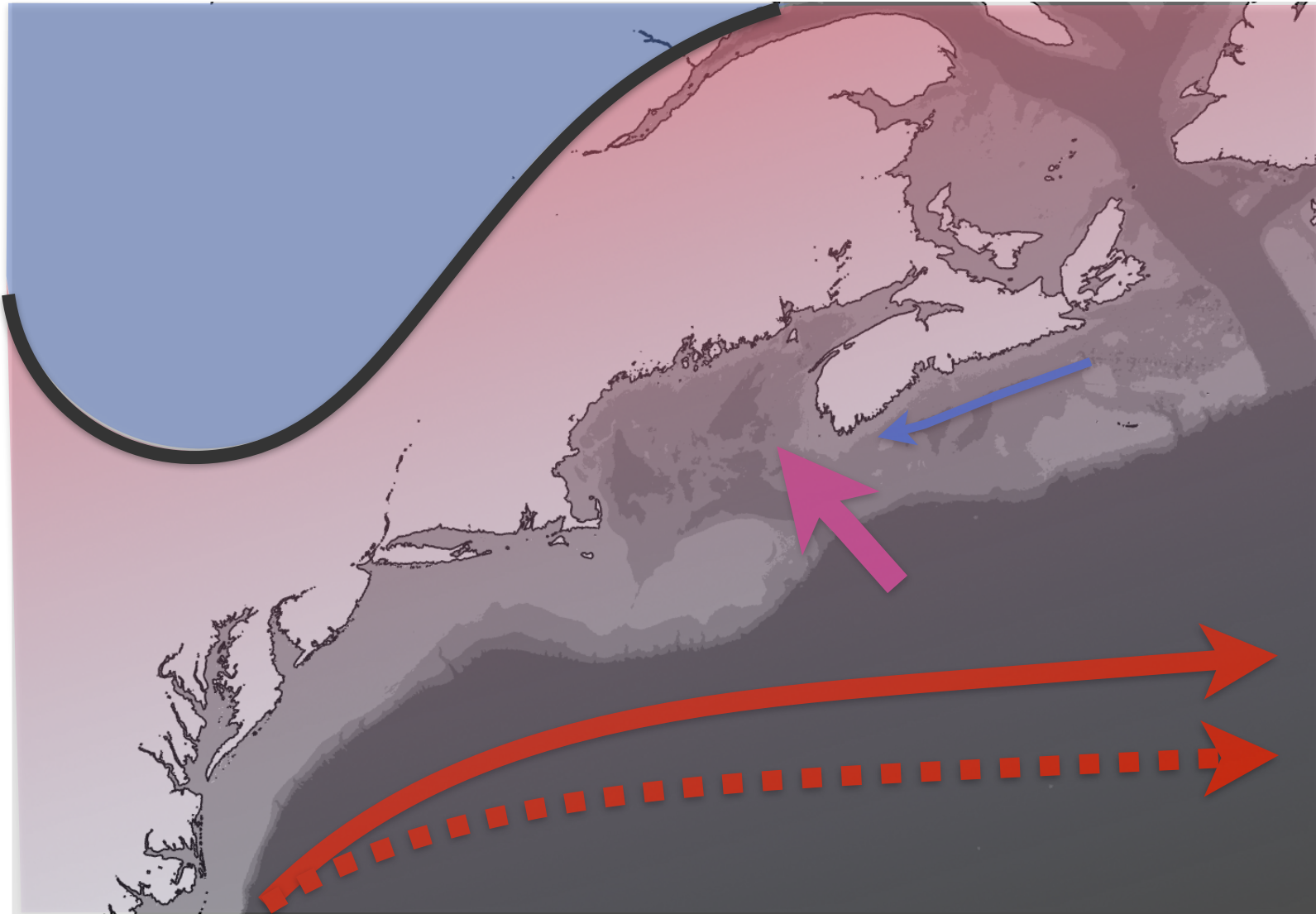
Gulf of Maine Warming



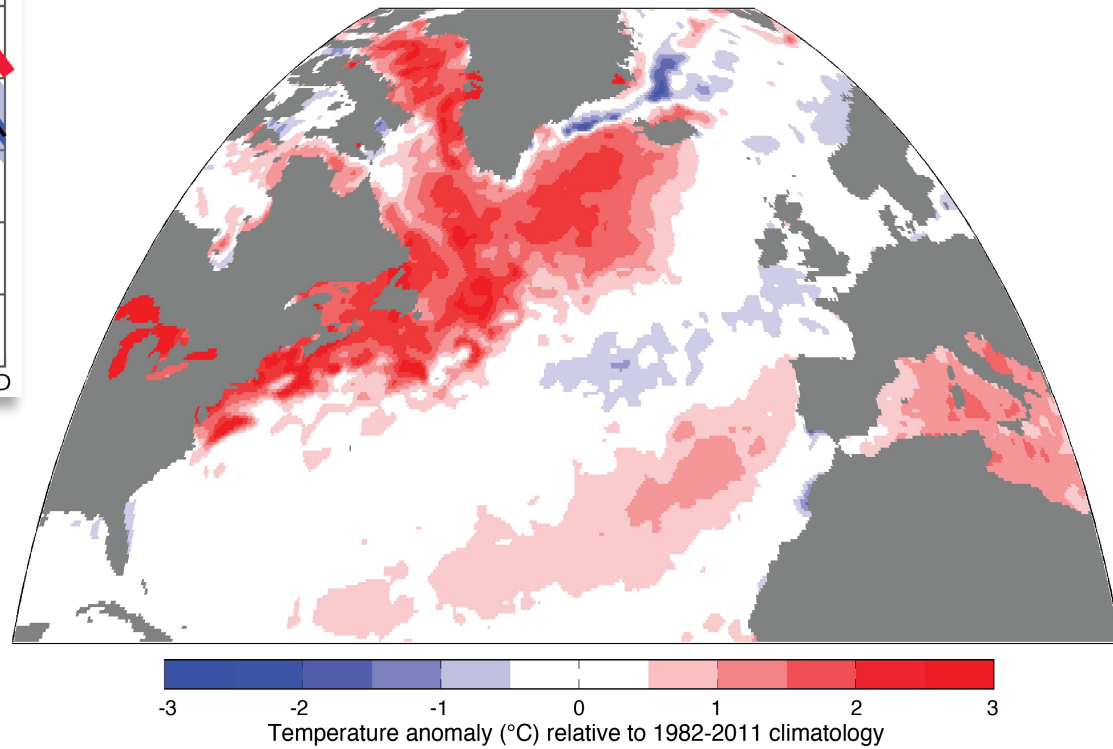
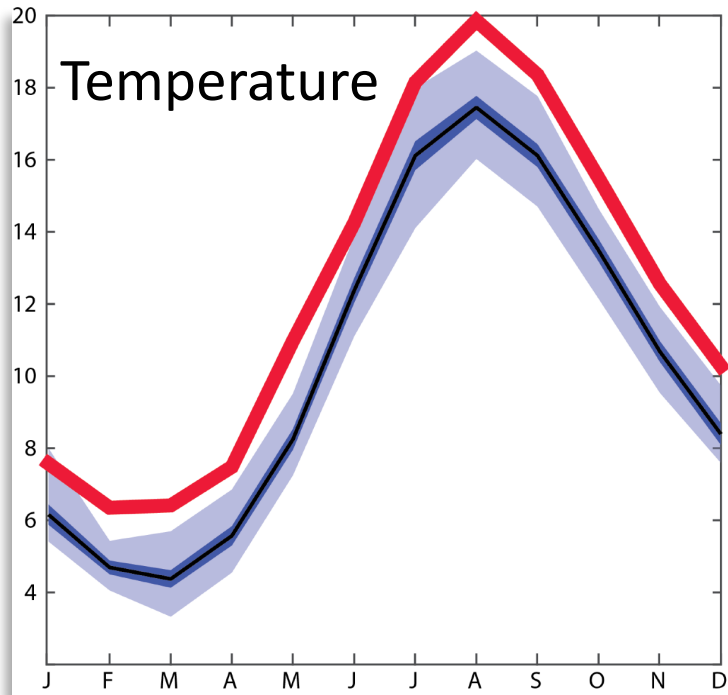
Gulf of Maine Warming



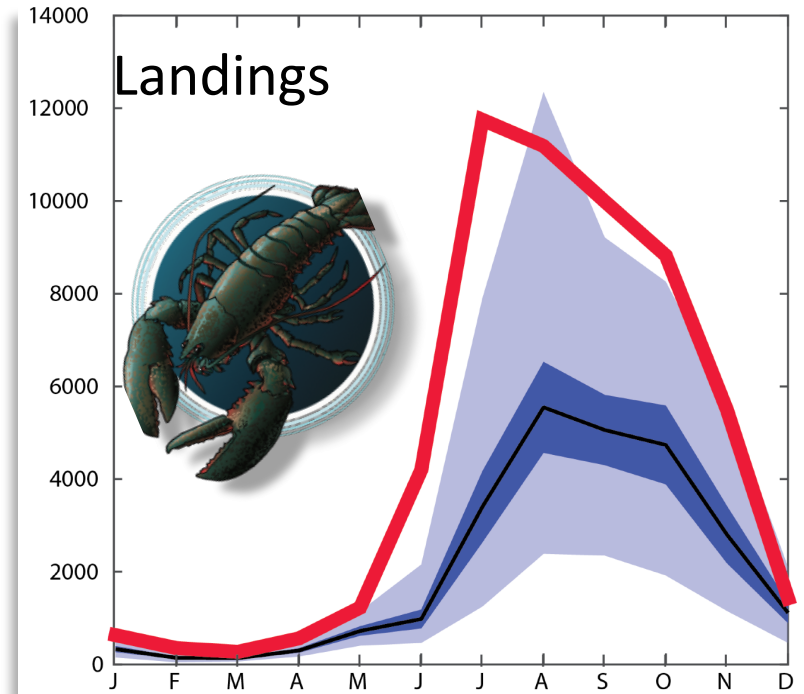
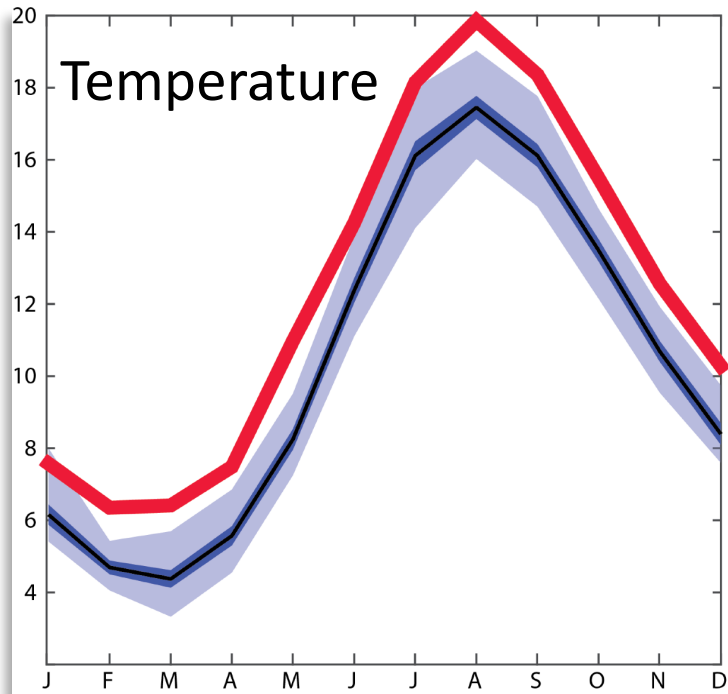
Gulf of Maine Warming



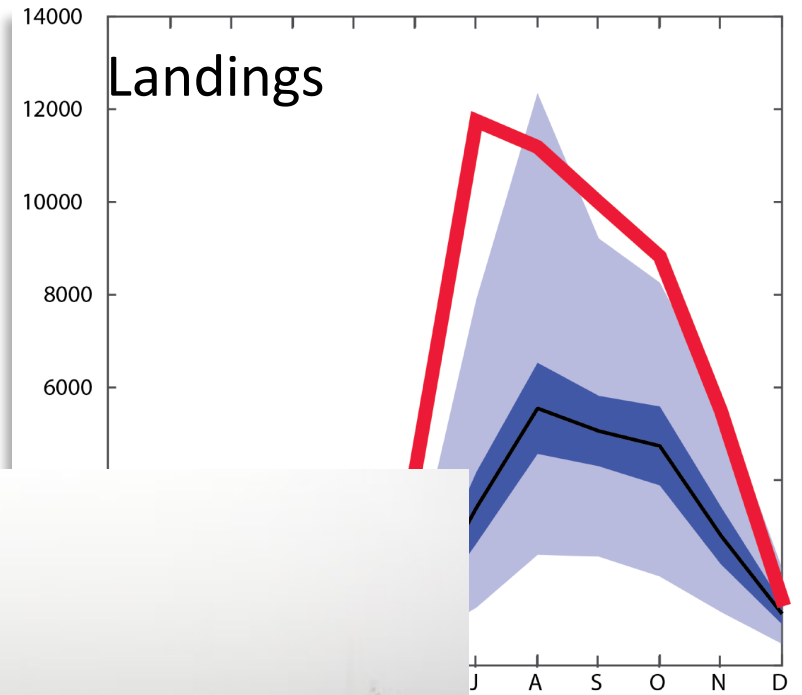
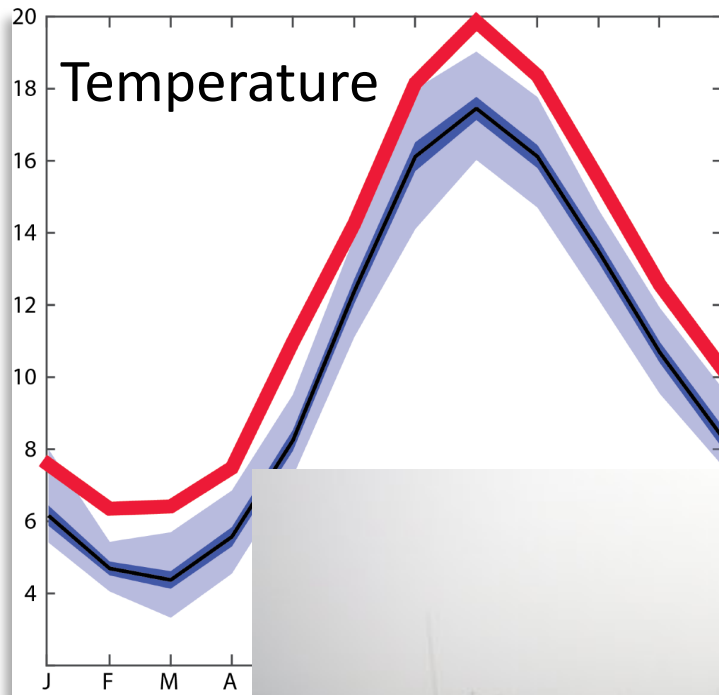
Impacts of 2012 heat wave



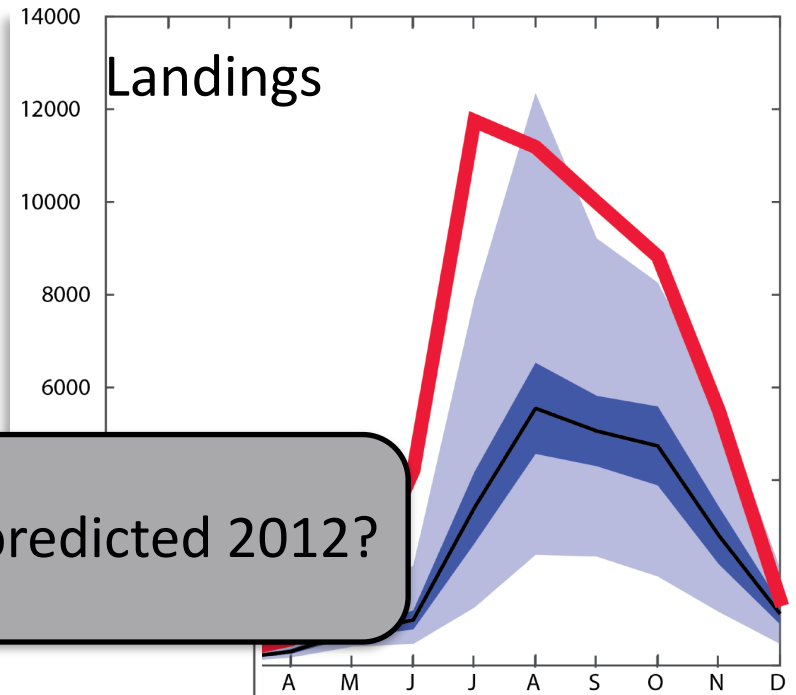
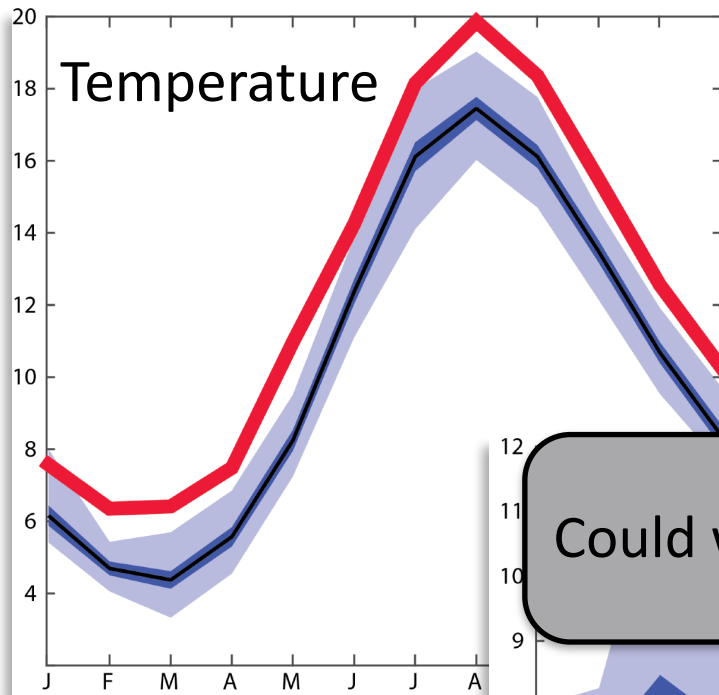
Impacts of 2012 heat wave



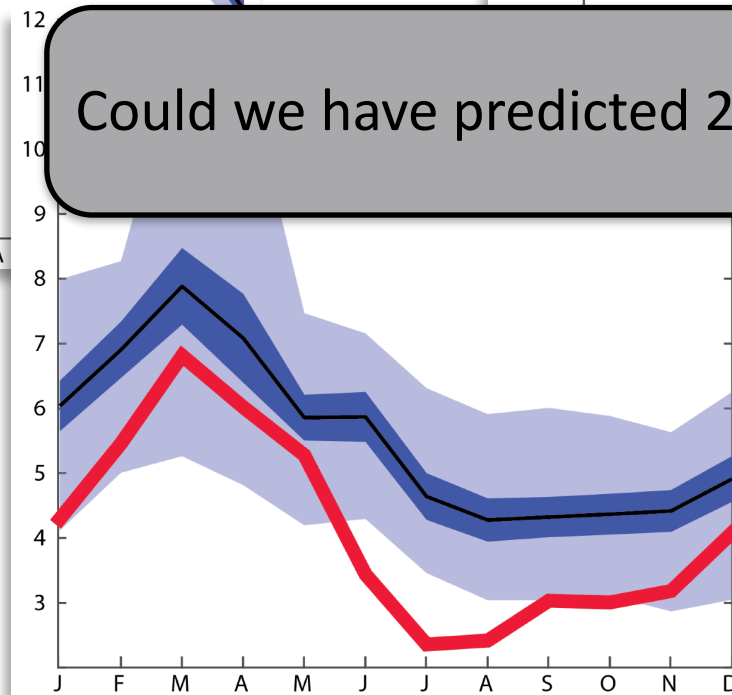
Impacts of 2012 heat wave



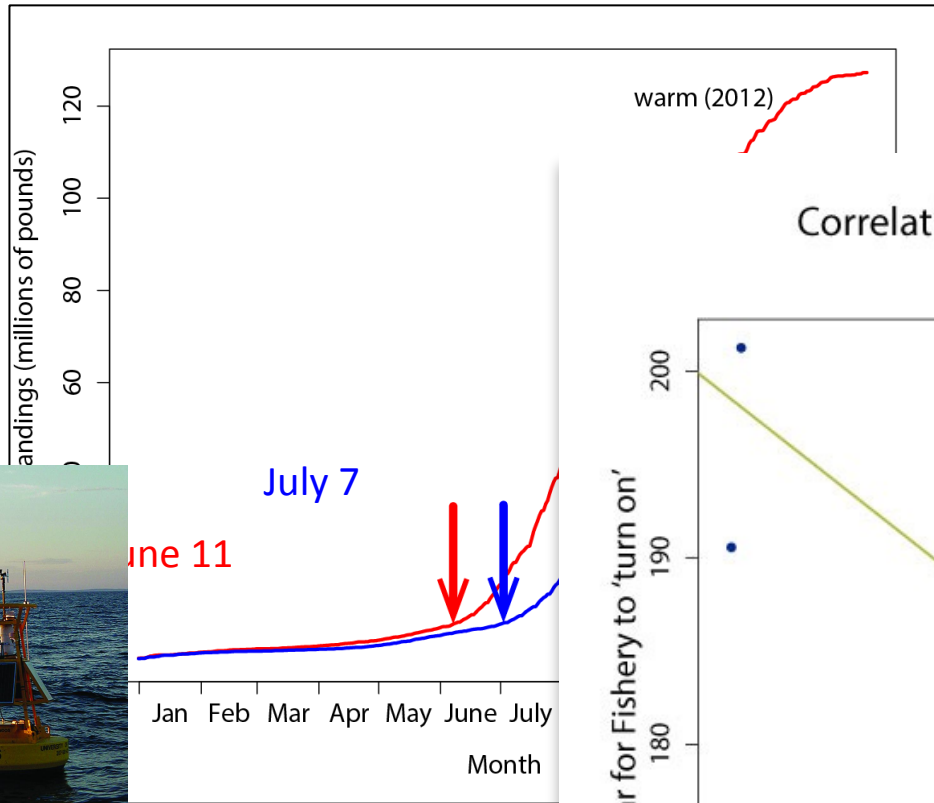
Impacts of 2012 heat wave



Could we have predicted 2012?



Temperature and Landings

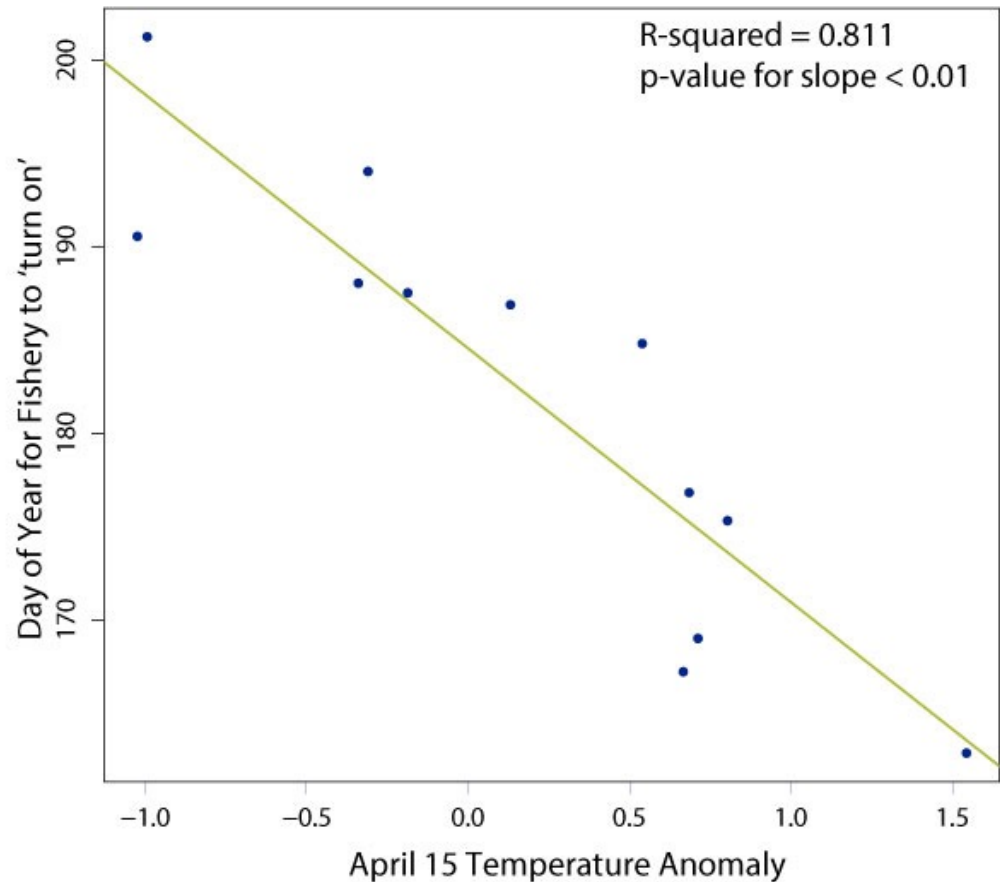


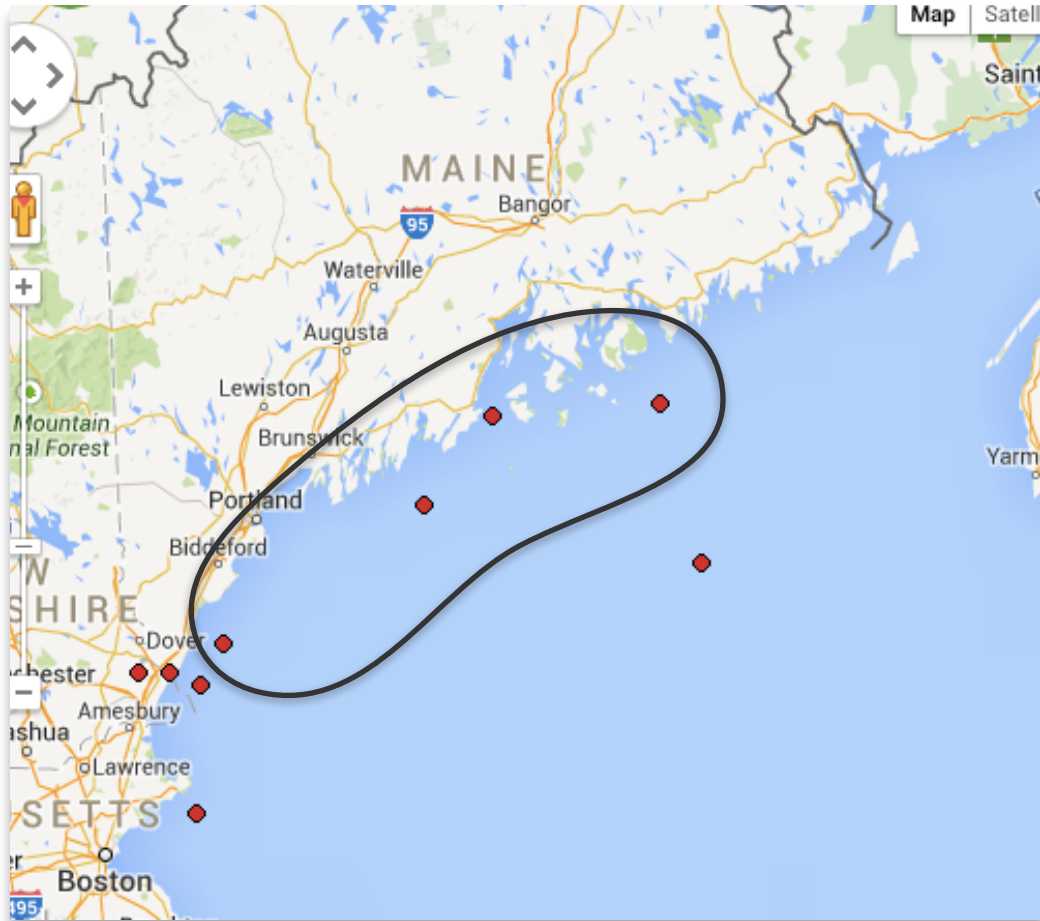
1m

20m

50m

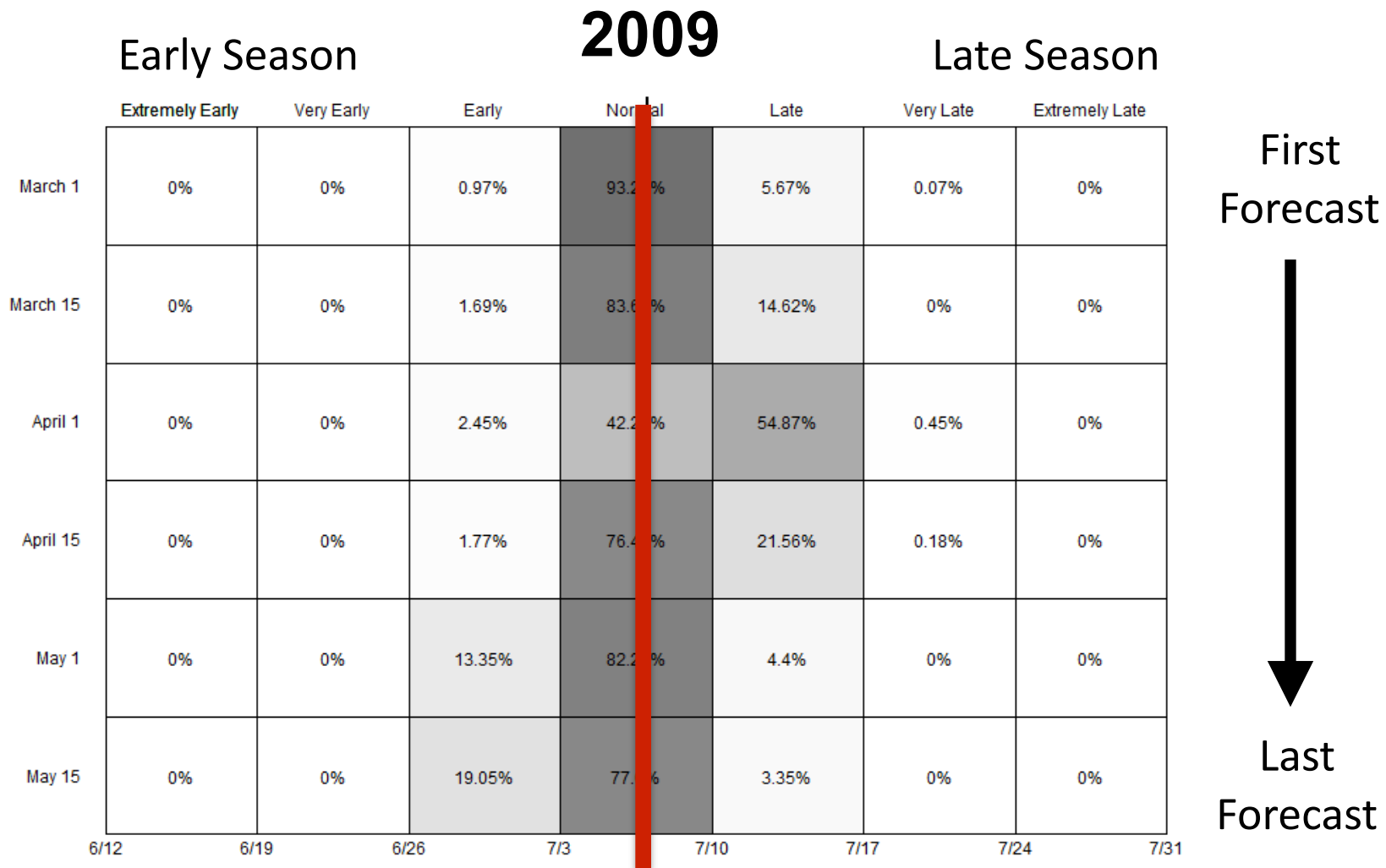
Correlation of Start Day and Temperature
2001-2013

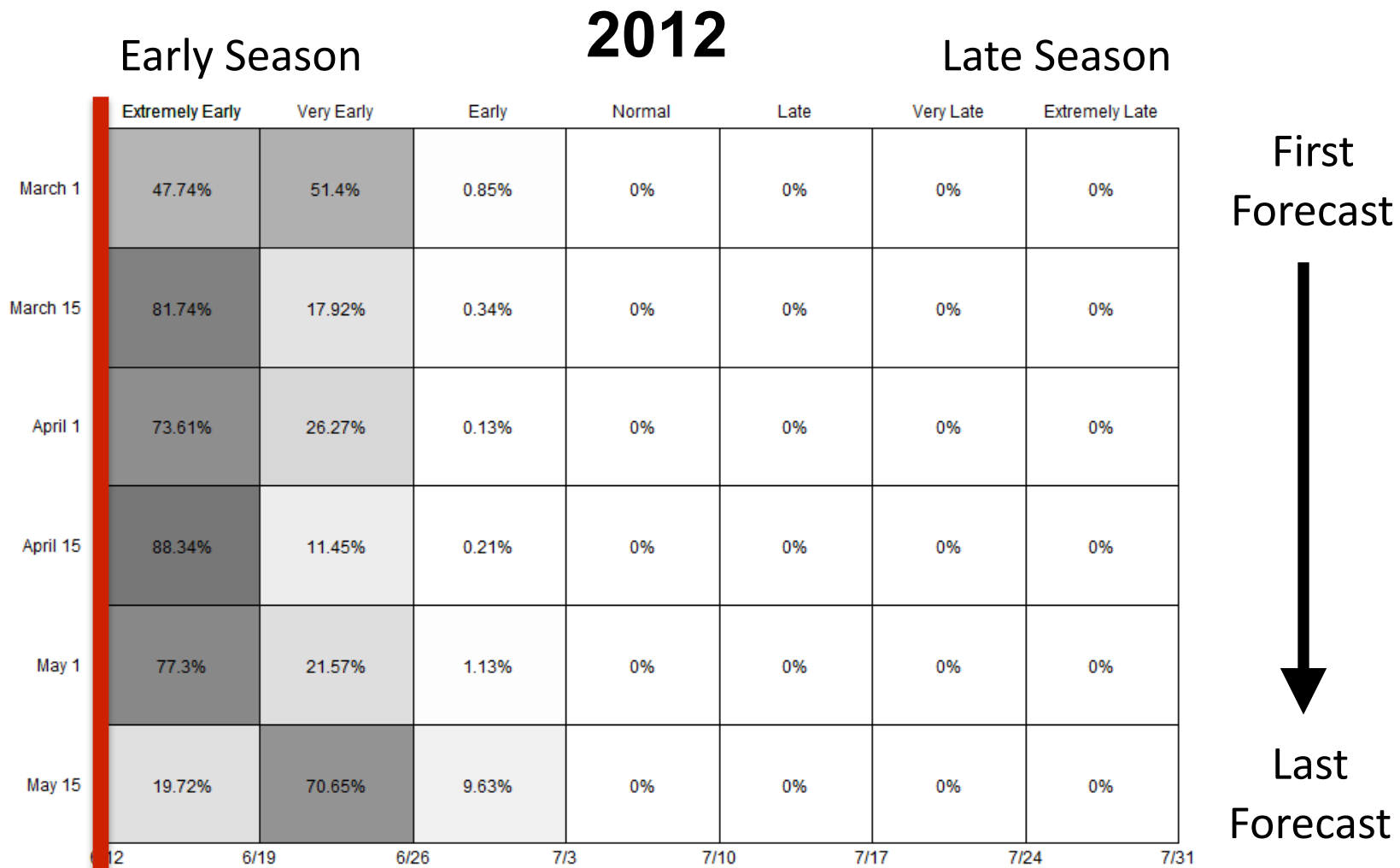


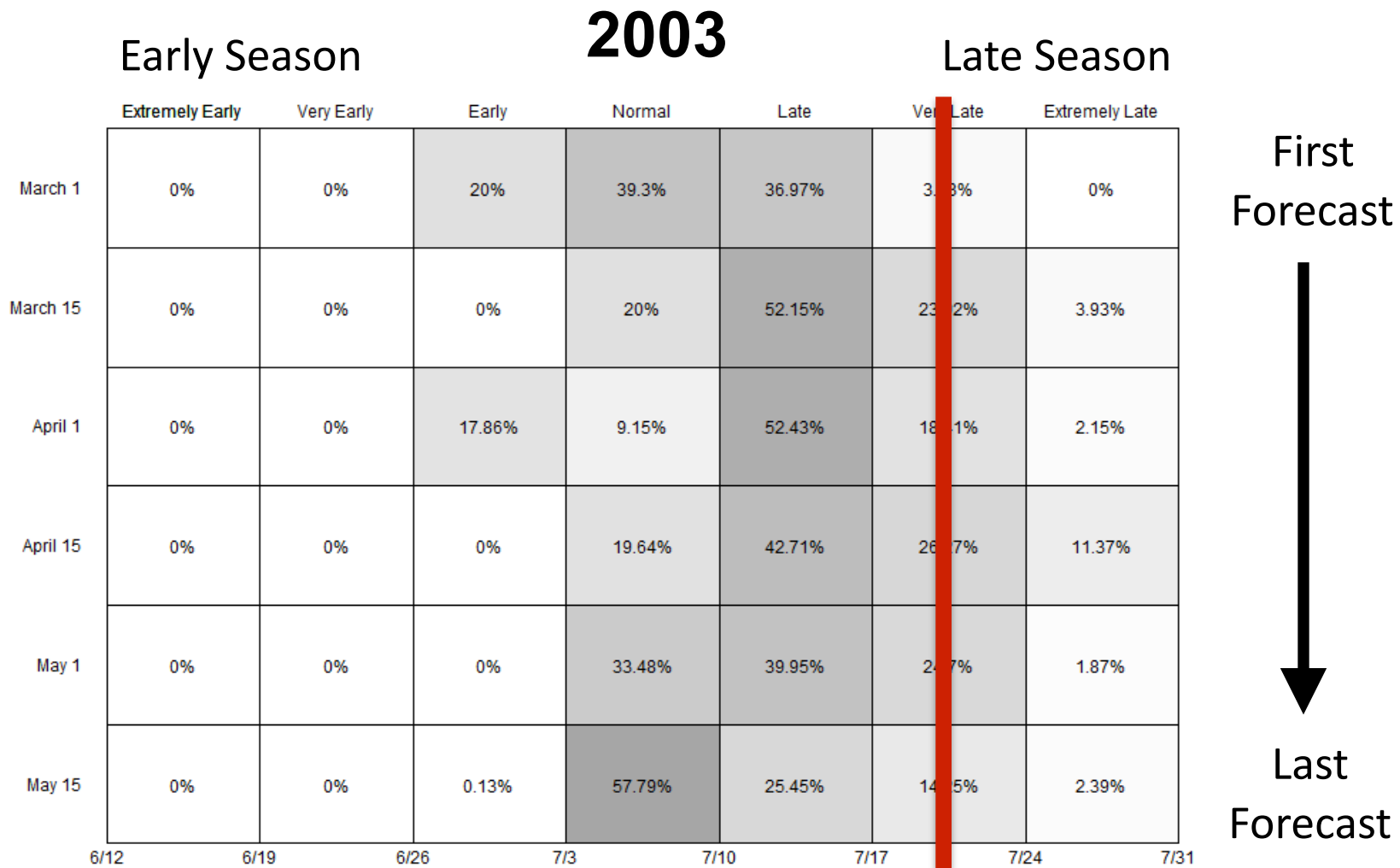


- linear models for 4 buoys + average
- randomly draw model coefficients and apply
- yields probability of start date in a time window

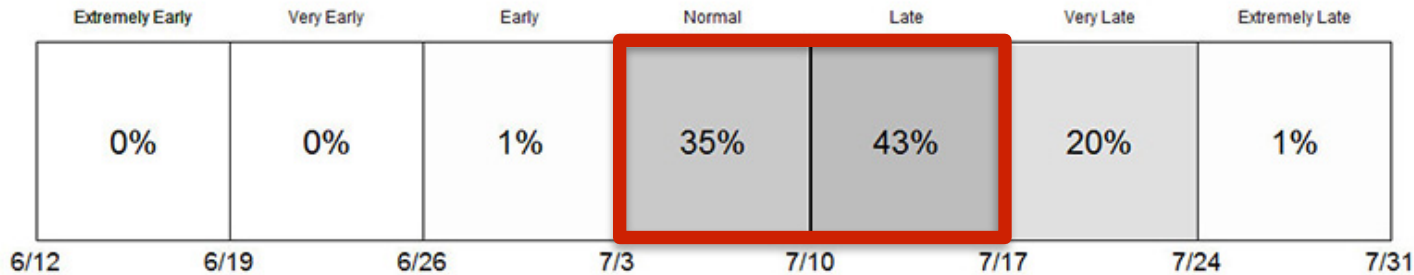
Hindcasts



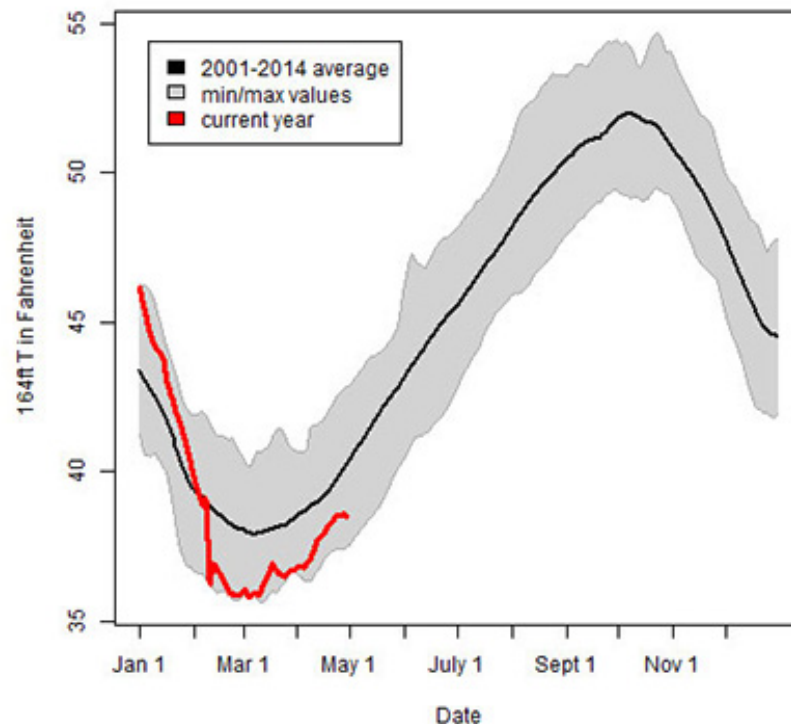




April 15 Forecast

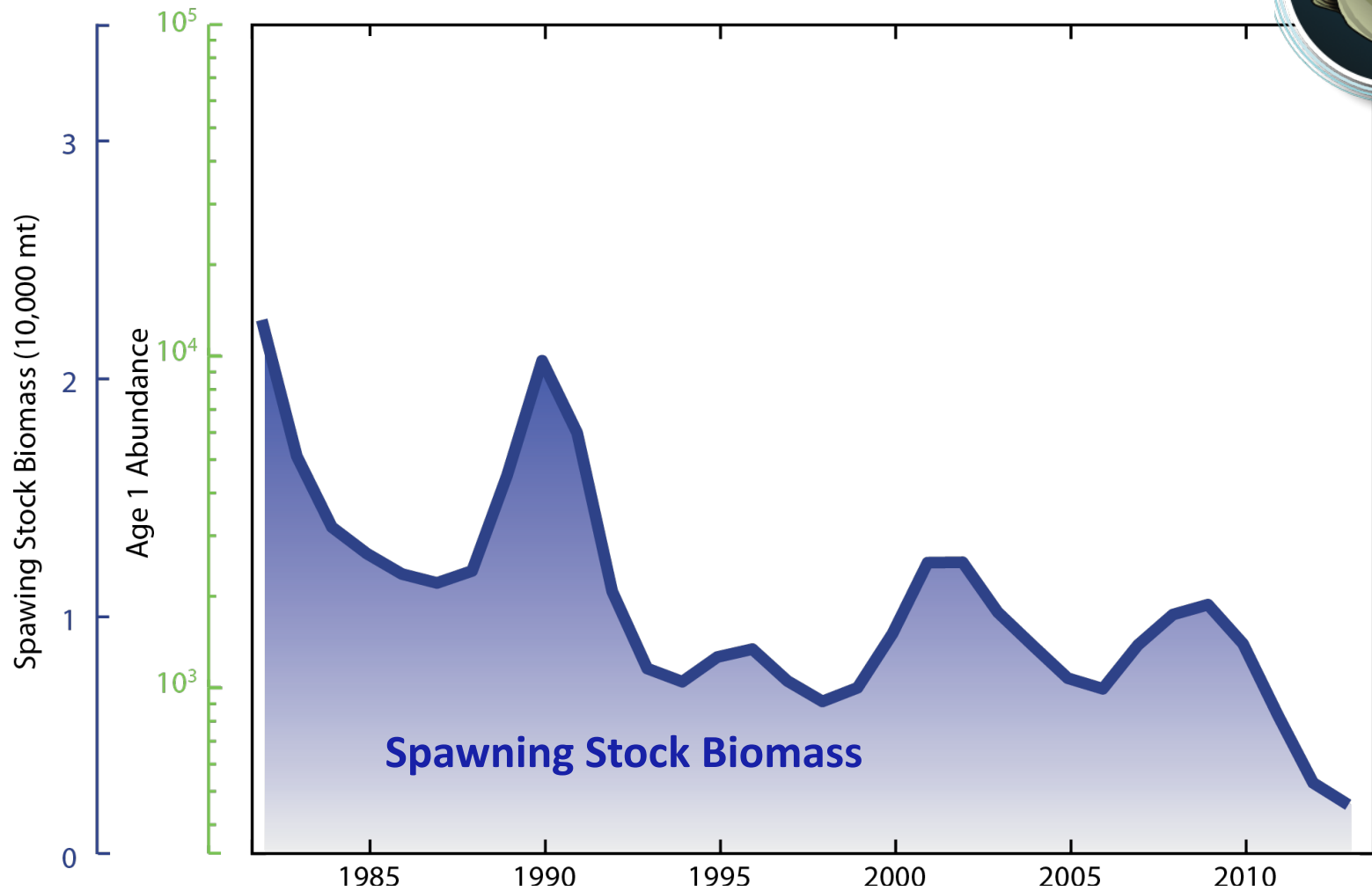


www.gmri.org/lobster-forecast



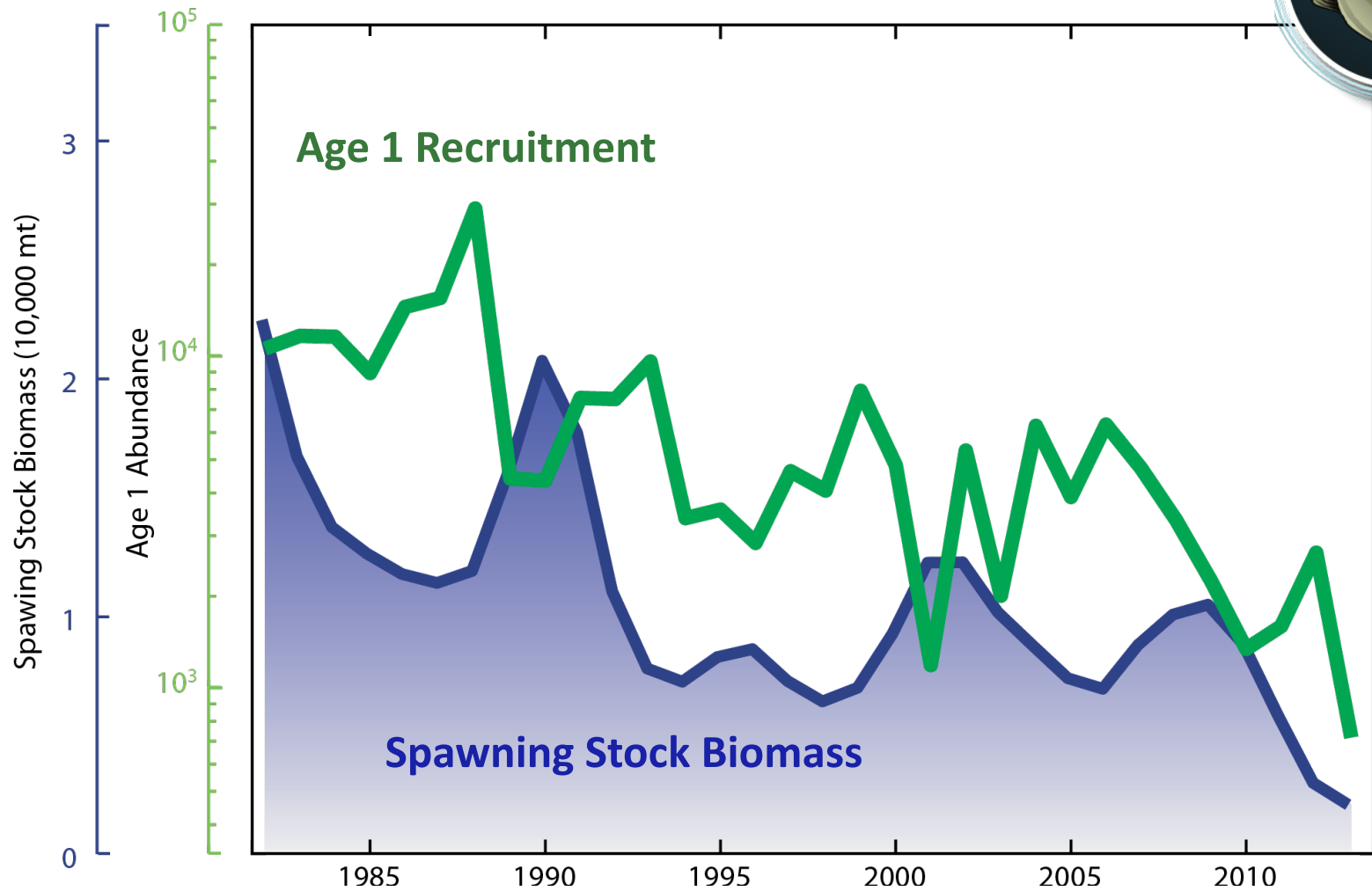
- 4/15—warming
- still cold
- late season, with a chance of very late

Gulf of Maine Cod



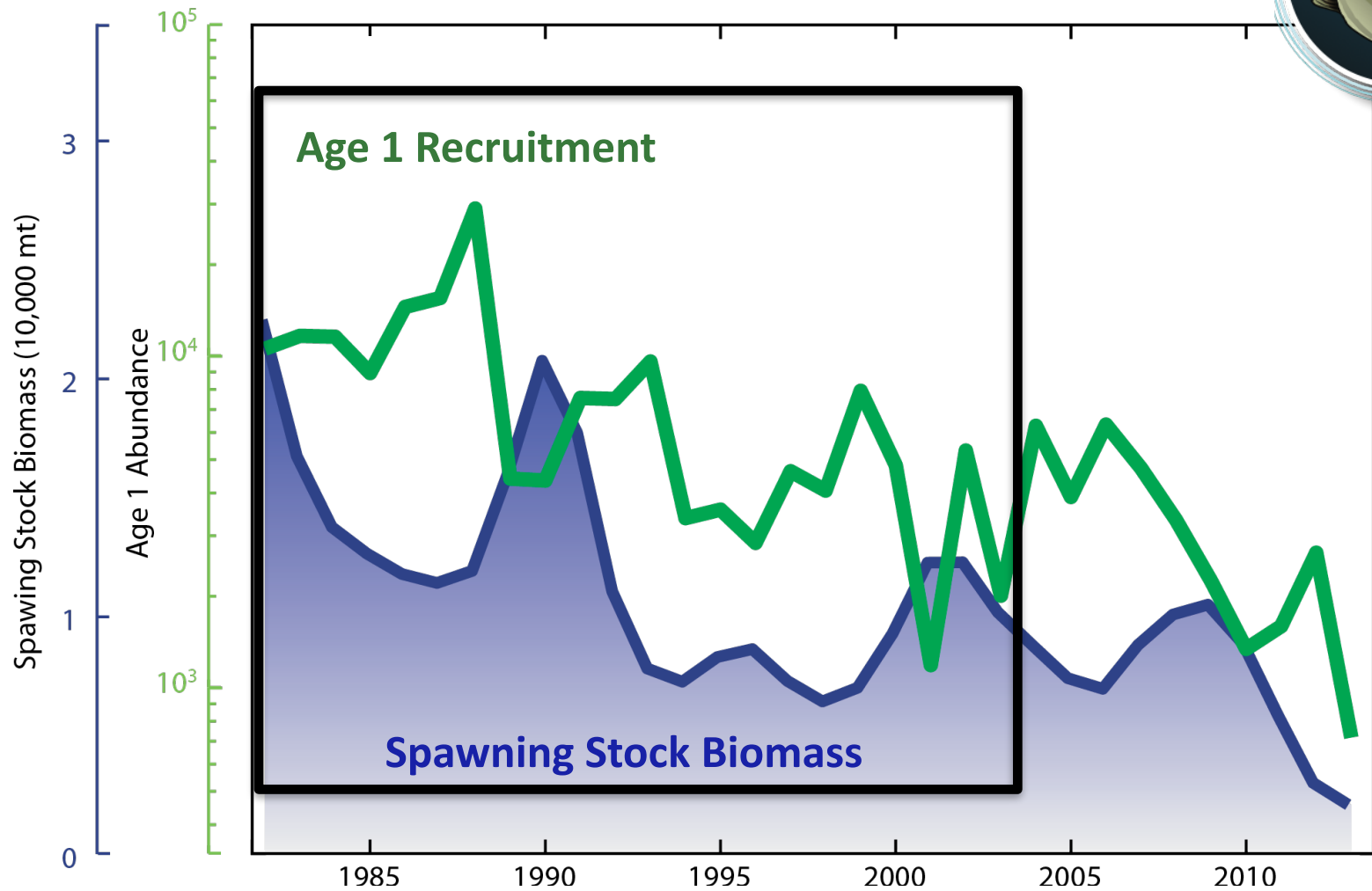
Data from 2014 stock assessment (Palmer, 2014)

Gulf of Maine Cod



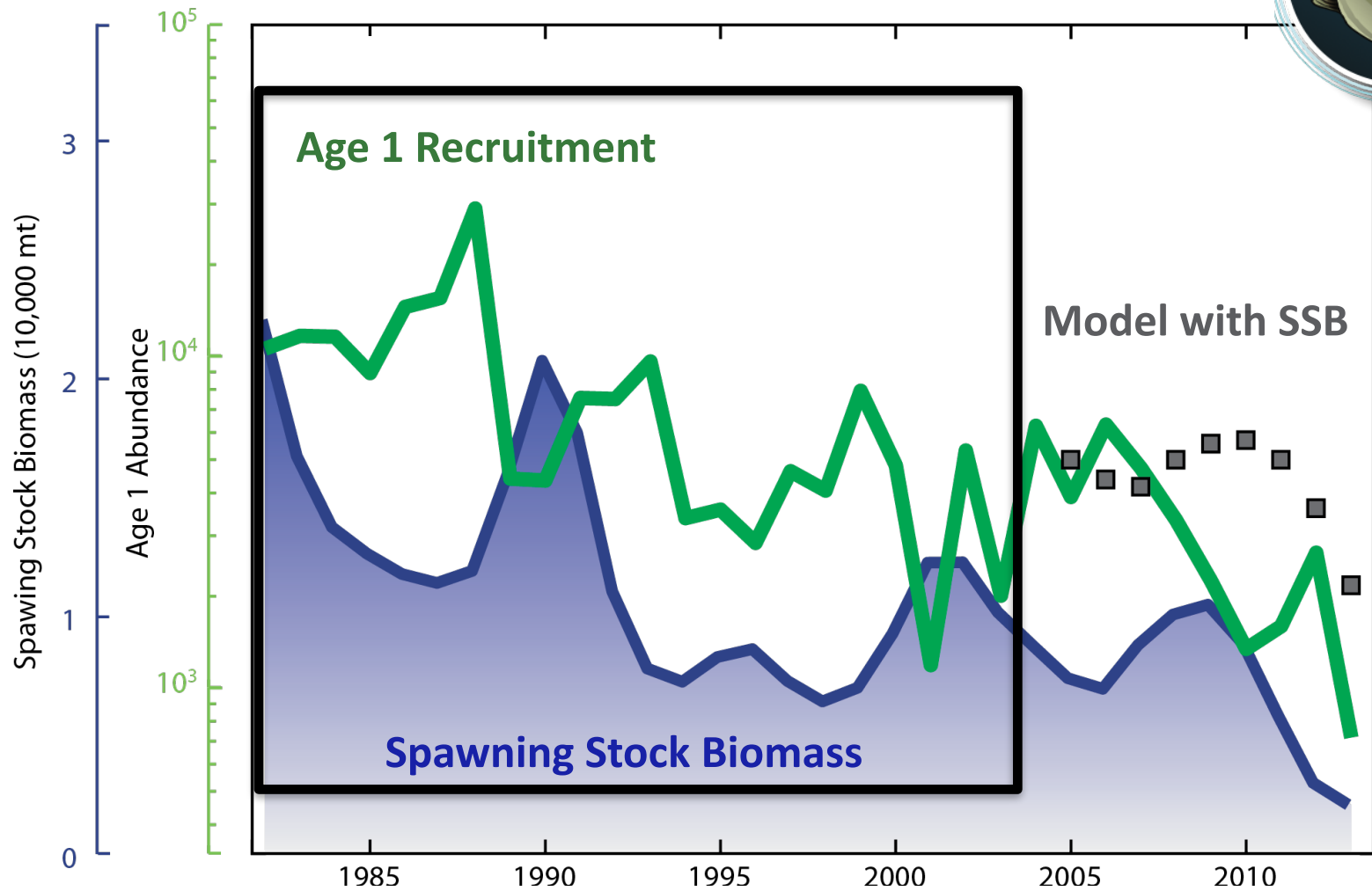
Data from 2014 stock assessment (Palmer, 2014)

Gulf of Maine Cod



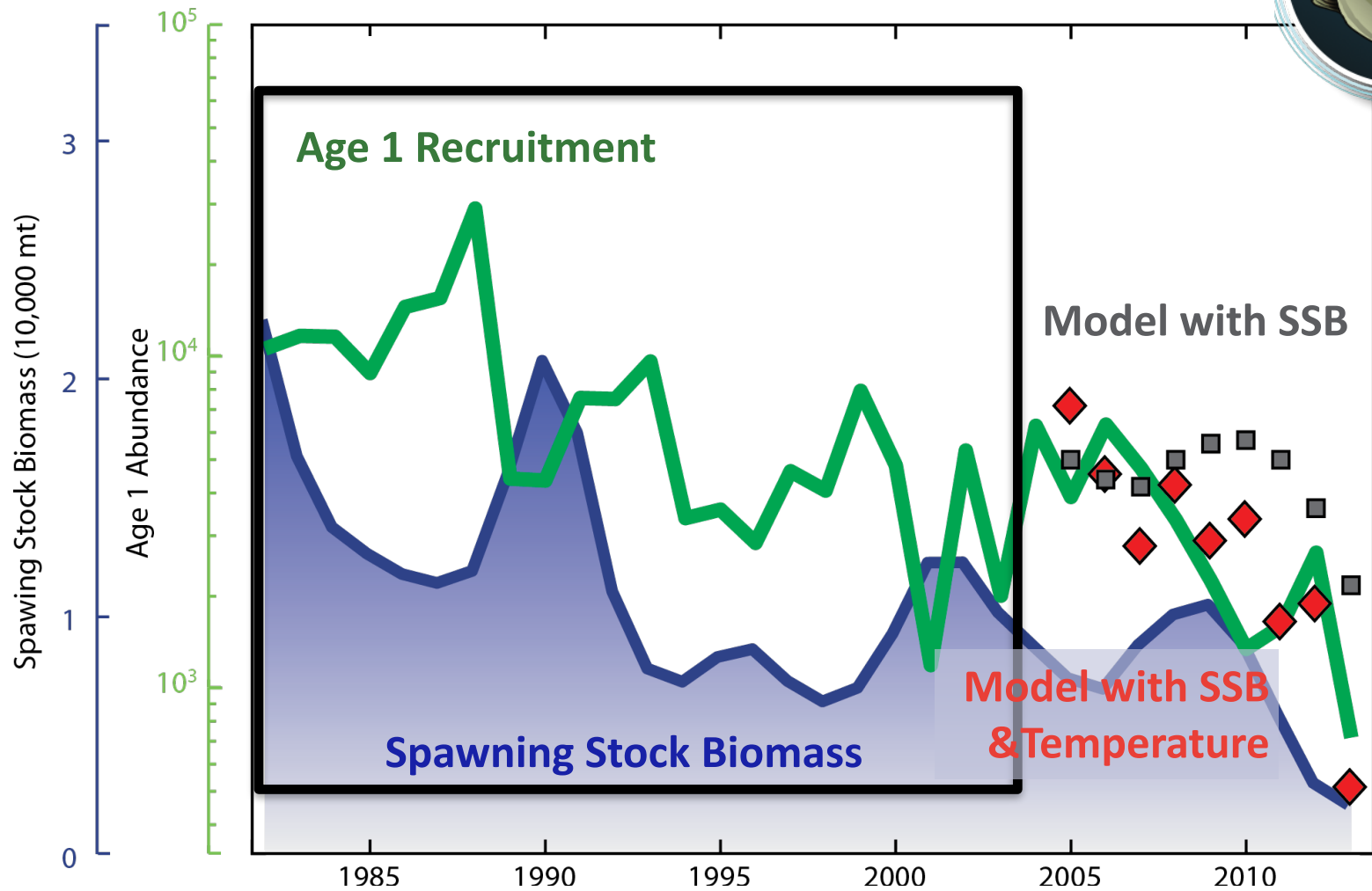
Data from 2014 stock assessment (Palmer, 2014)

Gulf of Maine Cod



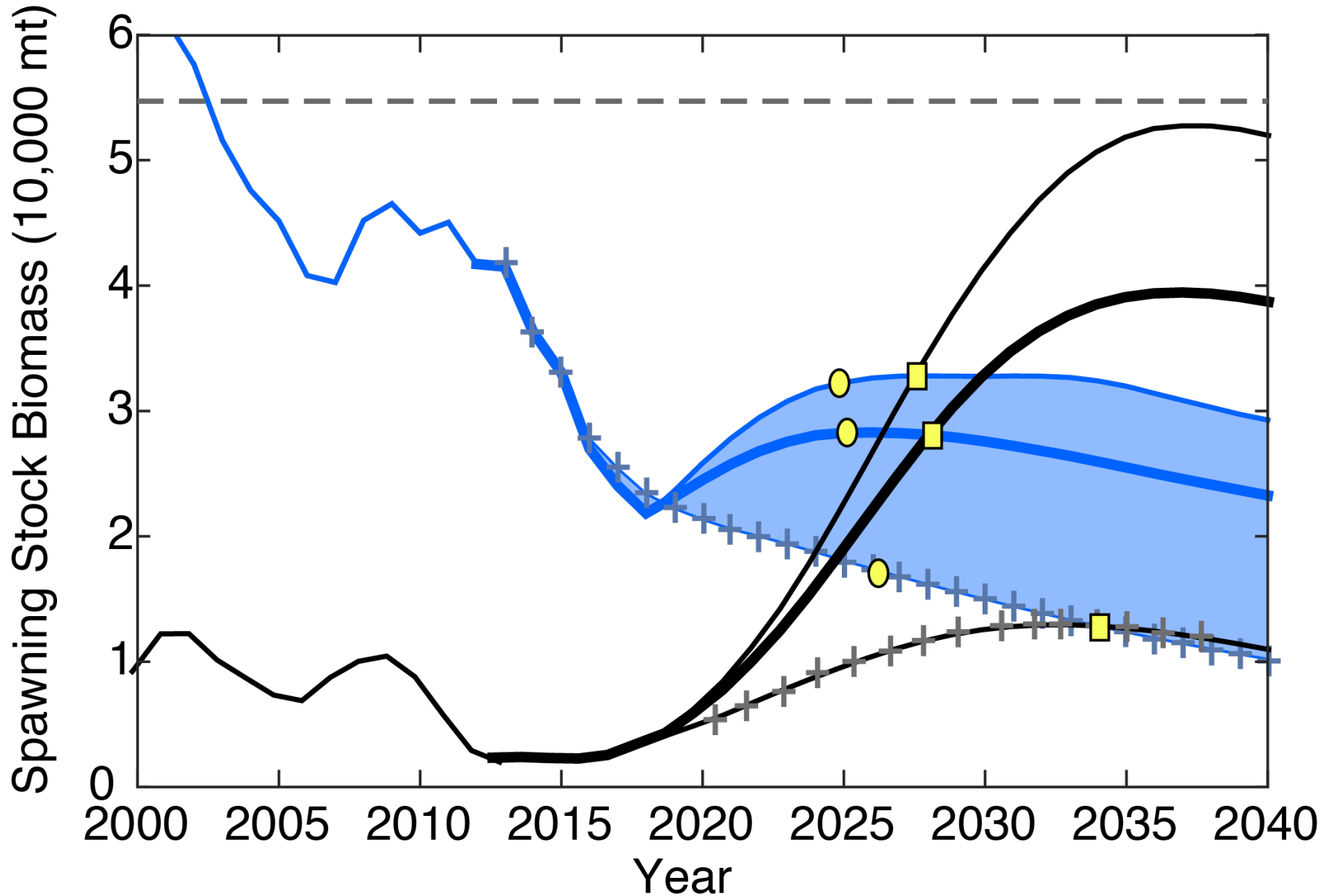
Data from 2014 stock assessment (Palmer, 2014)

Gulf of Maine Cod



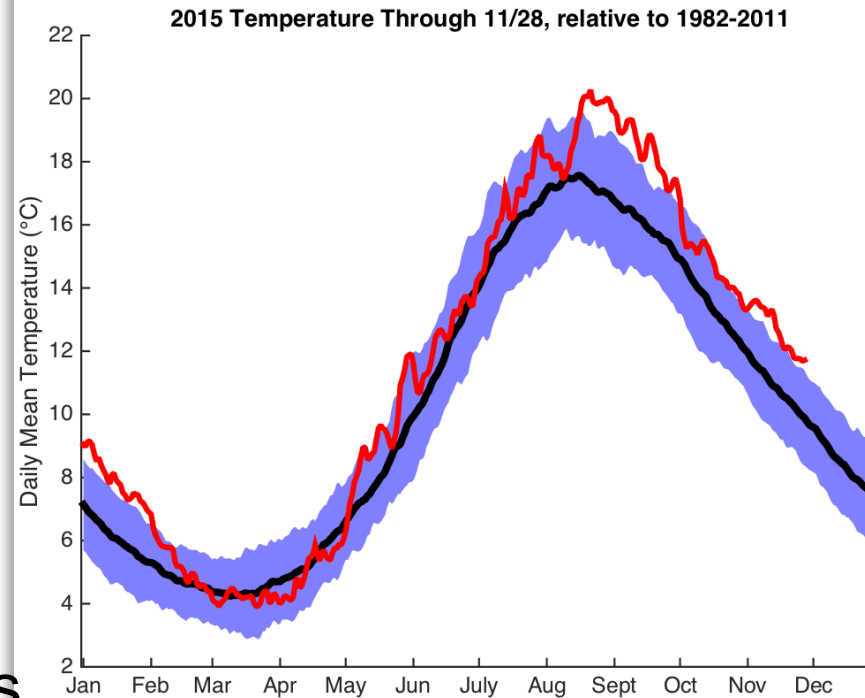
Data from 2014 stock assessment (Palmer, 2014)

Future of Cod



Conclusion

- The Gulf of Maine is warming rapidly
- Warming has impacted
 - fish distributions
 - fisheries management
 - fishermen
- Climate adaptation
 - incorporate environmental factors in decision-making
 - information and forecast tools
 - understand how humans make decisions



Pershing et al. 2015. Slow adaptation in the face of rapid warming leads to collapse of the Gulf of Maine cod fishery. *Science*, 350: 809-812.

Mills et al. 2013. Fisheries management in a changing climate: lessons from the 2012 ocean heat wave. *Oceanography*, 26: 191-195.